A novel multiple batch extraction test to assess contaminant mobilization from porous waste materials

Sascha C. Iden1, Markus Delay2, Fritz H. Frimmel2 and Wolfgang Durner1

1 Technische Universität Braunschweig, Institut für Geökologie, Langer Kamp 19c, 38106 Braunschweig www.soil.tu-bs.de
2 Universität Karlsruhe (TH), Engler-Bunte-Institut, Chair of Water Chemistry, Engler-Bunte-Ring 1, 76131 Kalsruhe, www.wasserchemie.uni-karlsruhe.de

Problem Statement

• One of the main objectives of current waste management policies is the reuse of waste materials, e.g. as fill materials which are deposited on natural deposits. The assessment of the environmental risk caused by such deposits to soil and groundwater requires thorough testing procedures which provide representative and reliable information about the release of inorganic and organic contaminants.
• Three key variables are of interest in risk assessments, (1) the liquid-phase concentration of a contaminant occurring in situ, (2) the total amount of contaminant which will be mobilized from the material in the long term, and (3) the temporal development of the emitted concentration
• Different types of laboratory testing have been developed. They can be categorized into batch extraction tests and column leaching tests.
• While single batch extraction cannot provide all necessary information on contaminant release, column leaching tests are often viewed as being too labor-intensive and too complex for practical use.

Parameter Estimation by MCMC

• A simple partitioning model is applied to the batch tests. It calculates the liquid phase concentration $c$ from the water-extractable amount of a compound $k_d$ and one or two isotherm parameters. In the case where a Freundlich isotherm with parameters $k_d$ and $n$ is used to describe the partitioning, the mole balance equation using an activity coefficient $\gamma$: $\gamma = 1 + kg \gamma^2$ for $\gamma > 0$
• Parameter estimation is performed in the Bayesian framework by applying a robust Markov Chain Monte Carlo algorithm (Wugt et al., 2003). All uncertainties (parameters, model predictions, desorption isotherms) are quantified.
• For every data set, we performed parameter estimation using a linear, a Freundlich, and a Langmuir isotherm. The most appropriate model was selected based on the deviance information criterion (DIC, Spiegelhalter et al., 2002).
• We estimated the parameters of the models given by equations (1)-(3) from the measured concentrations at the L/S ratios of 0.25 and 0.5 by the model and compared them to the measured concentrations for the purpose of verification.

Summary and Conclusions

• Both the excellent fit to the experimental data and a comparison between the model-estimated and independently measured concentrations show that the L/S ratios of 0.25 and 0.5 successfully demonstrate the applicability of the model for almost all studied extraction tests and both waste materials.
• We conclude that batch extraction tests at varying L/S ratios provide, at moderate experimental cost, a powerful complement to established test designs like column leaching or single batch extraction tests.
• The method constitutes an important tool in risk assessments, because concentrations at soil water contents representative of the long-term environmental situation can be predicted from ease-to-obtain test concentrations at larger L/S ratios.
• This helps to circumvent the experimental difficulties of the soil over-saturation and eliminates the need to apply statistical approaches to predict such representative concentrations which have been shown to suffer dramatically from poor correlations.

References


Software available

The software used in this study, a user manual and some sample files are available from the first author upon request. Please contact me by email: iden@tu-bs.de.